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Container-Grown Ponderosa Pine Seedlings Respond to Fertilization

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Fertilizing containerized ponderosa pine seedlings with Hoagland nutrient solution did not stimulate seedling growth in the greenhouse. Fertilization was then terminated and seedlings were planted in pots. Growth during the subsequent 7 months was significantly stimulated by the pre-fertilization. Seedlings planted in punched holes in compacted soil grew better than those planted in loose soil.

Keywords: Containerized seedlings, fertilizer, bulk density.

Planting nursery stock has been the most successful method of regenerating ponderosa pine in most areas of the Southwest (Heidman 1963, Schubert et al. 1970). However, planting is becoming increasingly more expensive. Natural regeneration and direct seeding measures, although less costly, are applicable only in special situations. Planting container-grown trees is an attractive alternative to seeding and planting nursery stock.

This Note reports the effect of fertilization in the greenhouse on the subsequent growth of these seedlings planted in cans of soil by two methods.

Methods

Six-month-old ponderosa pine seedlings raised in containers were grown an additional 6 months in a greenhouse under four fertilization regimes. The growing units measured 20 $\frac{1}{4}$ by 13 $\frac{3}{4}$ by 4 $\frac{1}{2}$ inches, and contained four compartments of 48 cells each, 1 inch in diameter and 4 $\frac{1}{2}$ inches deep. Each cell contained one ponderosa pine seedling growing in peat moss.

The four compartments in each unit were each randomly assigned one of the following treatments: full-, half-, or quarter-strength Hoagland nutrient solution, or water.

Fresh nutrient solution was mixed in a 20-liter carboy once a week and applied to the seedlings with a siphon. In addition, the seedlings were watered with plain water approximately twice a week.

After 6 months the fertilization was stopped, and 10 seedlings from each treatment were used to determine the oven-dry weights of tops and roots. At the same time, 200 seedlings, 50 from each treatment, were planted in pots containing a silty-clay loam soil collected from the Fort Valley Experimental Forest. The experimental design used was a split plot with five replications. Each replication consisted of five trees from each treatment planted to simulate the **dug-hole method** of planting, and five trees planted by a **punched-hole method** in compacted soil. Each replication therefore contained 40 seedlings.

Each pot was filled with 1,500 g of soil collected from the A and B soil horizons. For the dug-hole method of planting, the containerized seedling with its associated soil was held in place in the pot and the soil filled in around it. The soil in pots used for the punched-hole planting method was compacted as follows: each pot received 200 ml of water to bring it to approximate field capacity. After 2 hours the pots were tamped three times on a concrete floor. Each

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pot then received 50 ml of water every other day for the next 14 days. Pots were then allowed to dry for 10 days. One containerized seedling was planted in each pot in a hole created by pounding a steel dowel into the soil. The bulk density of the dug-hole method was 1.02; of the punched-hole method, 1.28.

Pots were arranged in blocks on the floor of the greenhouse and re-randomized weekly. Each pot received from 100 to 150 ml of plain water weekly from an automatic pipette. The temperature in the greenhouse ranged from 60° to 85°F.

The study was terminated in December after seedlings had grown in pots for 7 months. Top height and stem diameter of each seedling were determined, as well as the ovendry weight of the top and roots. The data were analyzed for significant differences by analysis of variance.

Results

Trees fertilized with one-fourth strength Hoagland nutrient solution were darker green than trees fertilized with full- or half-strength solution (fig. 1). The latter two were yellowish, although the yellow disappeared 2 months after planting. Thus full- and half-strength solutions may have been toxic to the seedlings.

Ovendry weights (table 1) of the tops and roots after fertilization showed no significant differences among treatments. After growing in pots for 7 months, however, seedlings did show responses to the fertilizer treatments. Seedlings fertilized with Hoagland solutions were superior to seedlings receiving only water (table 2). For root weights (fig. 2), the

Table 1.—Growth of 1-year-old ponderosa pine seedlings as affected by Hoagland nutrient solution

Treatment number and solution strength	Mean ovendry weight ¹			Mean seed- ling height ² - - - Grams - - - Milli- meters
	Top	Root	Total	
I--Full	0.3549	0.2796	0.6345	66
II--Half	.3892	.4159	.8051	70
III--Quarter	.3361	.4289	.7650	73
IV--Water only	.2516	.3009	.5525	64

¹10 seedlings from each treatment.

²50 seedlings from each treatment.

differences among treatments were significant ($P<.01$). Fertilization significantly ($P<.01$) increased stem diameter compared to water only, but there were no significant differences among the three concentrations of nutrient solution. Top height growth was not significantly different among the three solution treatments.

Seedlings planted by the punched-hole method grew better than seedlings planted by the dug-hole method. For seedlings planted by the punched-hole method (1) top growth was significantly greater at $P=.10$, (2) root weights were significantly greater at $P<.01$, and (3) top weights were significantly greater at $P=.05$.



Figure 1.—One-year-old containerized ponderosa pine seedlings after 6 months of fertilization in the greenhouse. Note the vigor of the tops of the fertilized seedlings I, II, and III as compared to IV (which received only water).

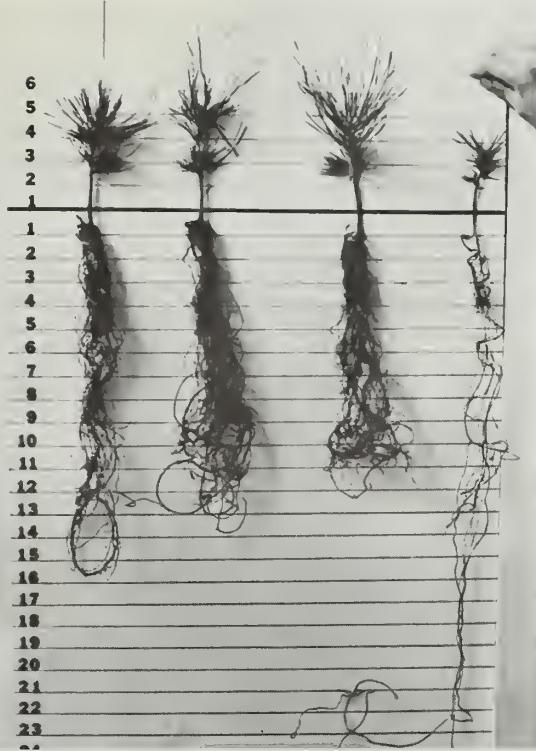


Figure 2.—Root growth of ponderosa pine seedlings (planted in loose soil) continued responding to fertilization while growing in pots for 7 months. Note vigor of tops and especially roots of the fertilized seedlings (left to right) I, II, and III as compared to IV (which received only water).

Table 2.--Effects of fertilizer treatments and planting methods on growth of ponderosa pine seedlings after 7 months in a greenhouse (mean of 25 seedlings)

Method, treatment number, and solution strength	Ovendry weight		Stem diam- eter	Top growth incre- ment
	Top	Root		
-- Grams -- Millimeters				
DUG-HOLE:				
I--Full	1.26	1.78	3.9	13.0
II--Half	1.17	1.66	4.1	16.8
III--Quarter	1.51	2.14	3.9	16.1
IV--Water only	0.74	1.20	3.1	15.8
Total	4.68	6.78	15.0	61.7
PUNCHED-HOLE:				
I--Full	1.56	2.22	4.2	18.0
II--Half	1.48	2.35	4.0	16.2
III--Quarter	1.35	1.99	3.9	16.0
IV--Water only	1.01	1.49	3.5	16.0
Total	5.40	8.05	15.6	66.2

Summary and Conclusions

Three strengths of Hoagland nutrient solution did not stimulate seedling growth during 6 month's fertilization in the greenhouse, but seedlings receiving quarter-strength solution appeared to be healthiest.

During 7 month's growth after planting, however, seedling growth was stimulated by the pre-fertilization. All nutrient strengths were superior to water, but there were no significant differences among strengths. Therefore, quarter strength is most practical since it produced the best overall growth at least cost.

The punched-hole planting method resulted in superior tree growth, perhaps because of better soil water-root relations. The compacted soil quite possibly resulted in better capillary flow of water. The uncompacted soil most likely had more air-filled pores (Heidmann 1974).

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